

ASPIRATING SEAL GE90 TEST

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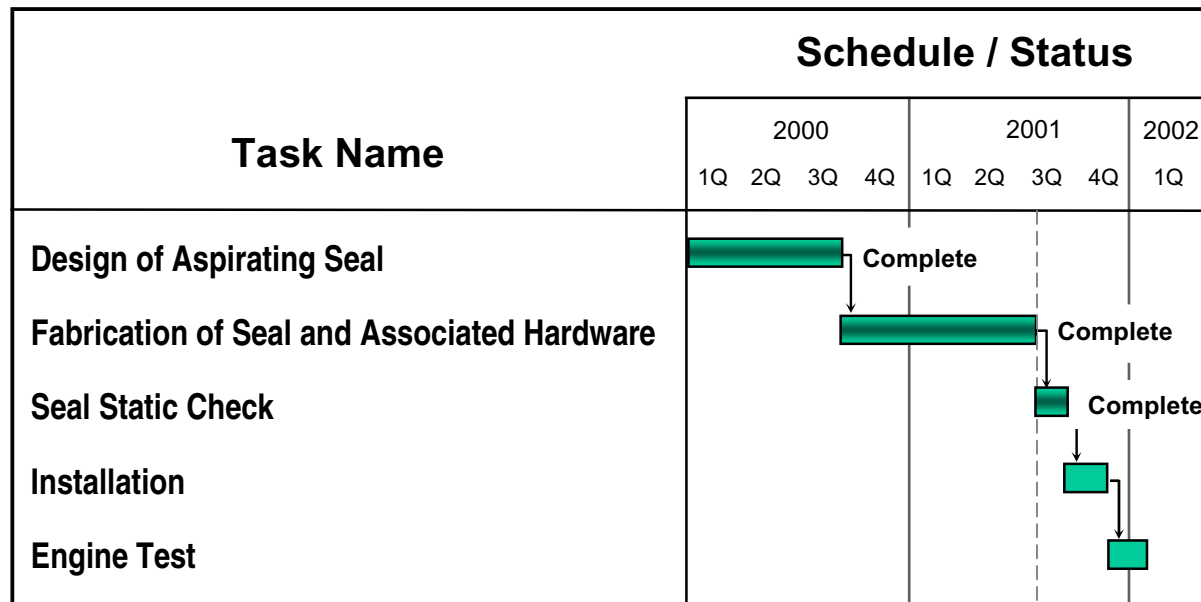
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Aspirating Seal GE90 Test

Objective: Complete the Development of the Aspirating Seal for Engine Applications by Demonstrating the Seal in the GE90 Engine After Rig Verification

Payoffs:

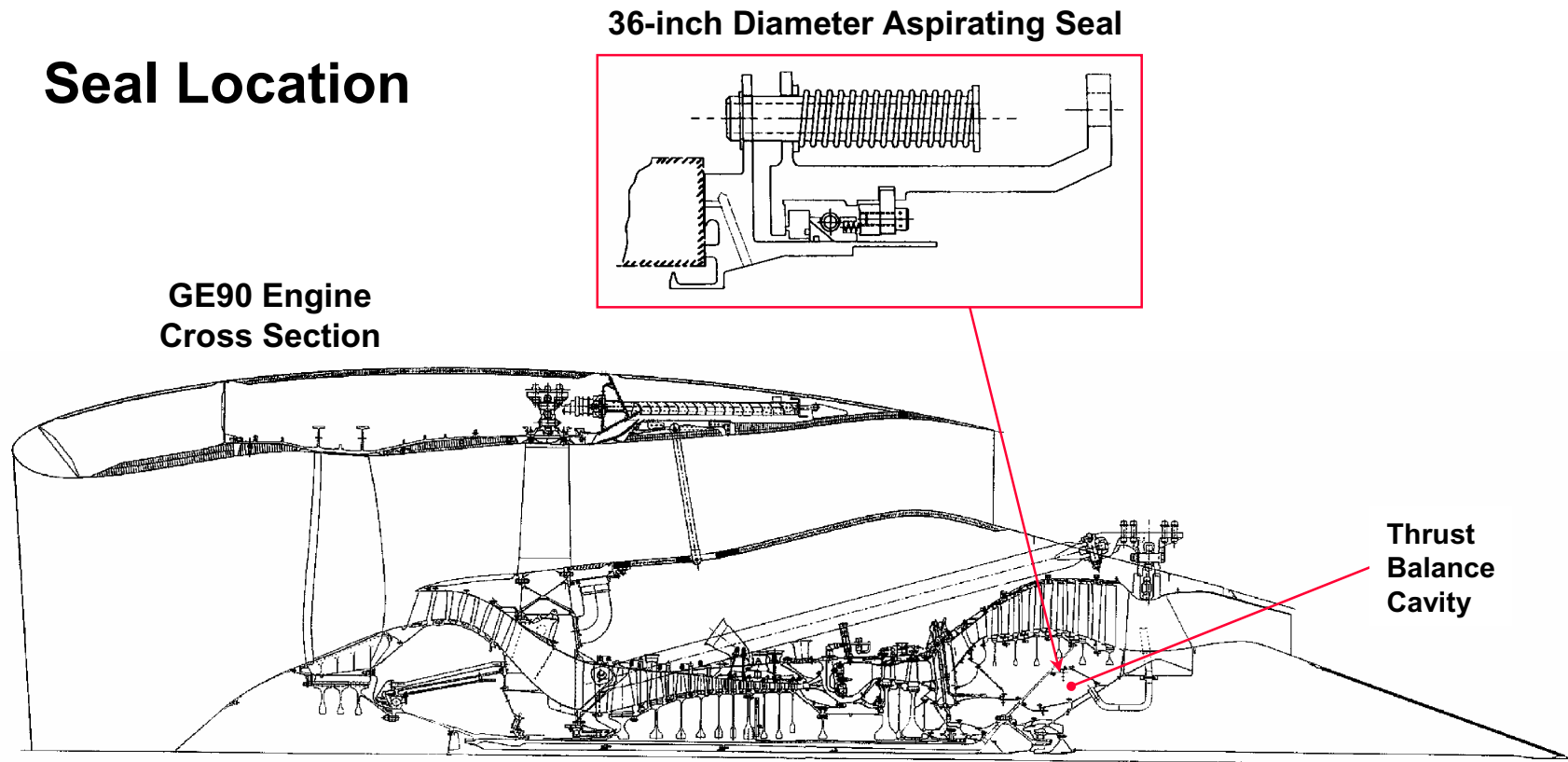
- Leakage <1/5th Labyrinth Seal
- Operates Without Contact for Long Life.
- Decreases SFC by 1.86% and DOC+I by 0.69% for Three Locations



Supports Level 1 Milestone: Aspirating Seal Demonstration (March 2002)

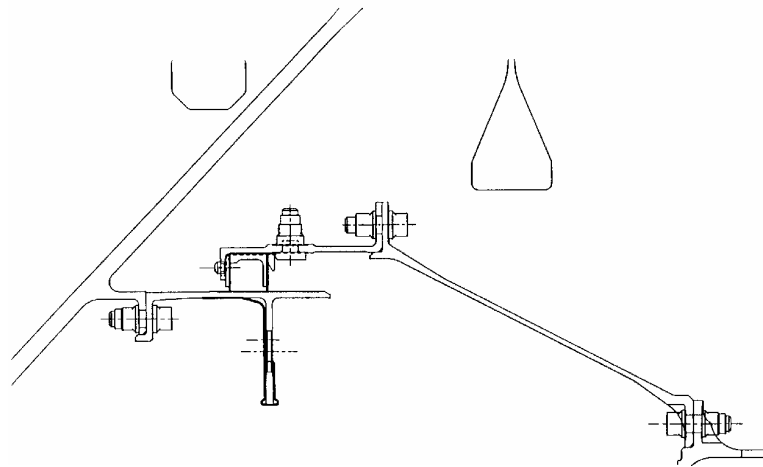
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Seal Location

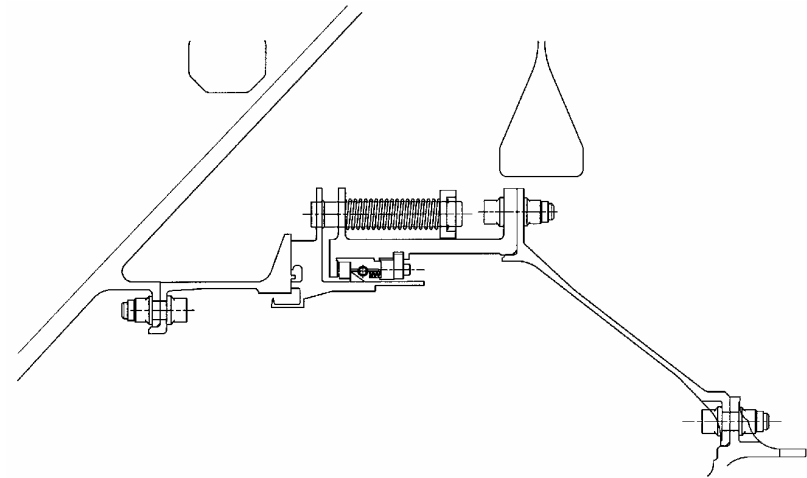


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Seal Position



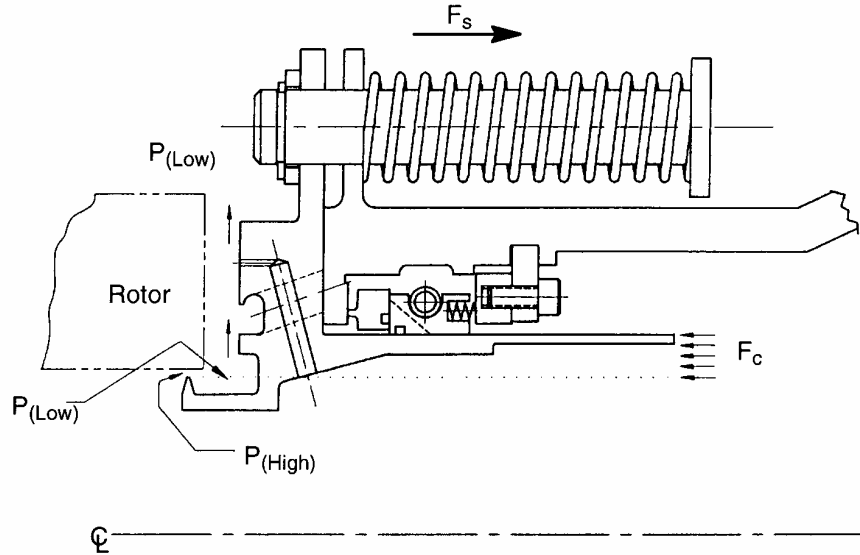
Production



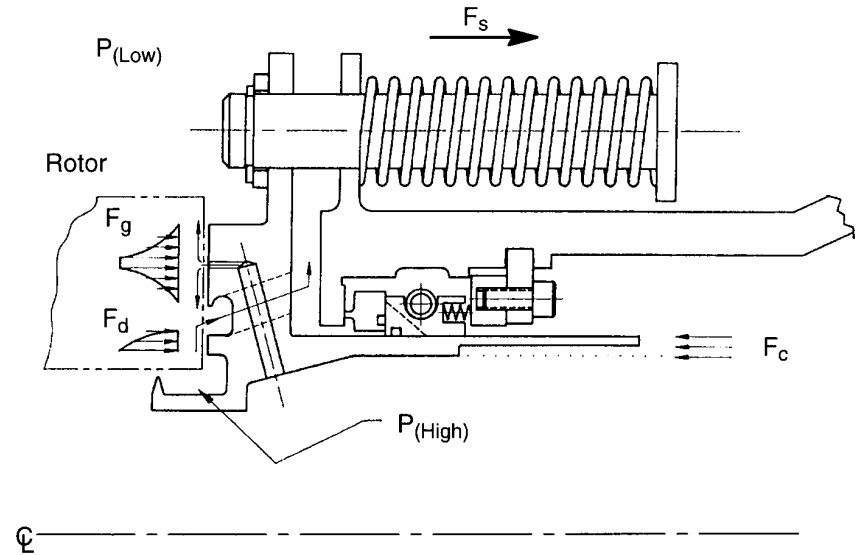
Aspirating Seal

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Aspirating Seal



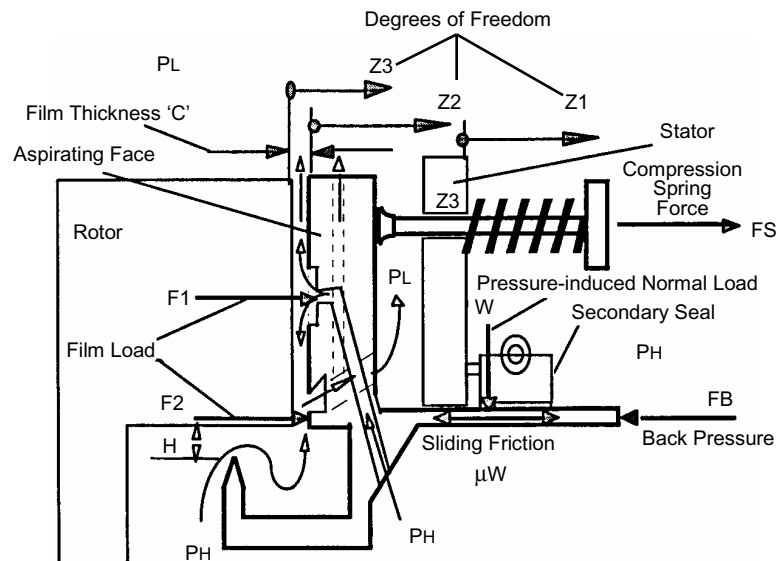
Aspirating Seal at Shutdown Phase



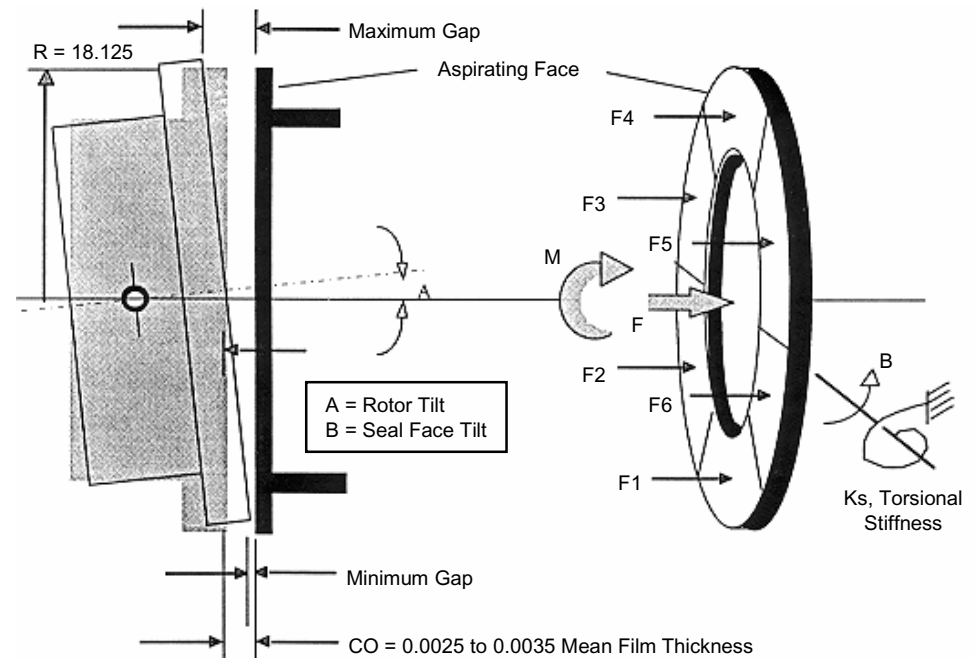
Aspirating Seal at Steady-State Operation

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Seal Analytical Model



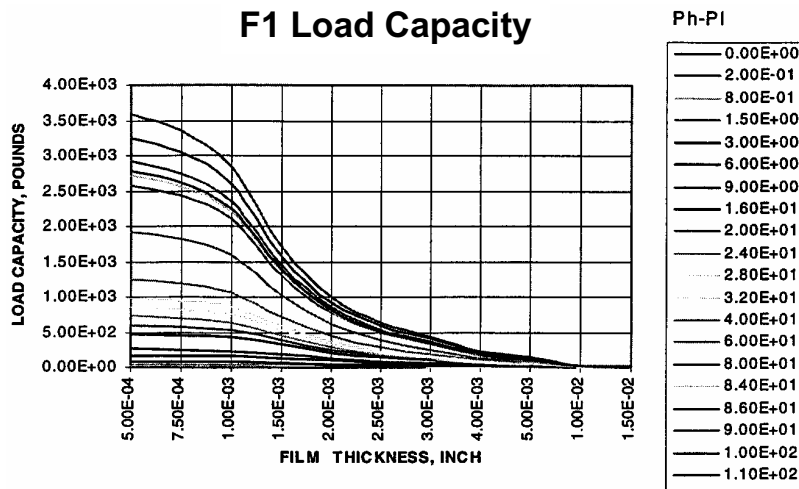
Transient Dynamic Model of an Aspirating Face Seal



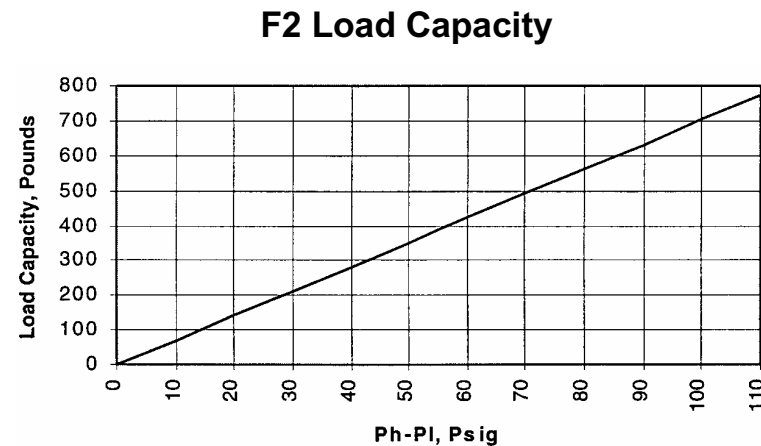
Tilt Analysis of an Aspirating Seal

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Seal Analytical Model



Variation of Load Capacity, F1, of the Main Hydrostatic Film Bearing with Film Thickness and Pressure Drop

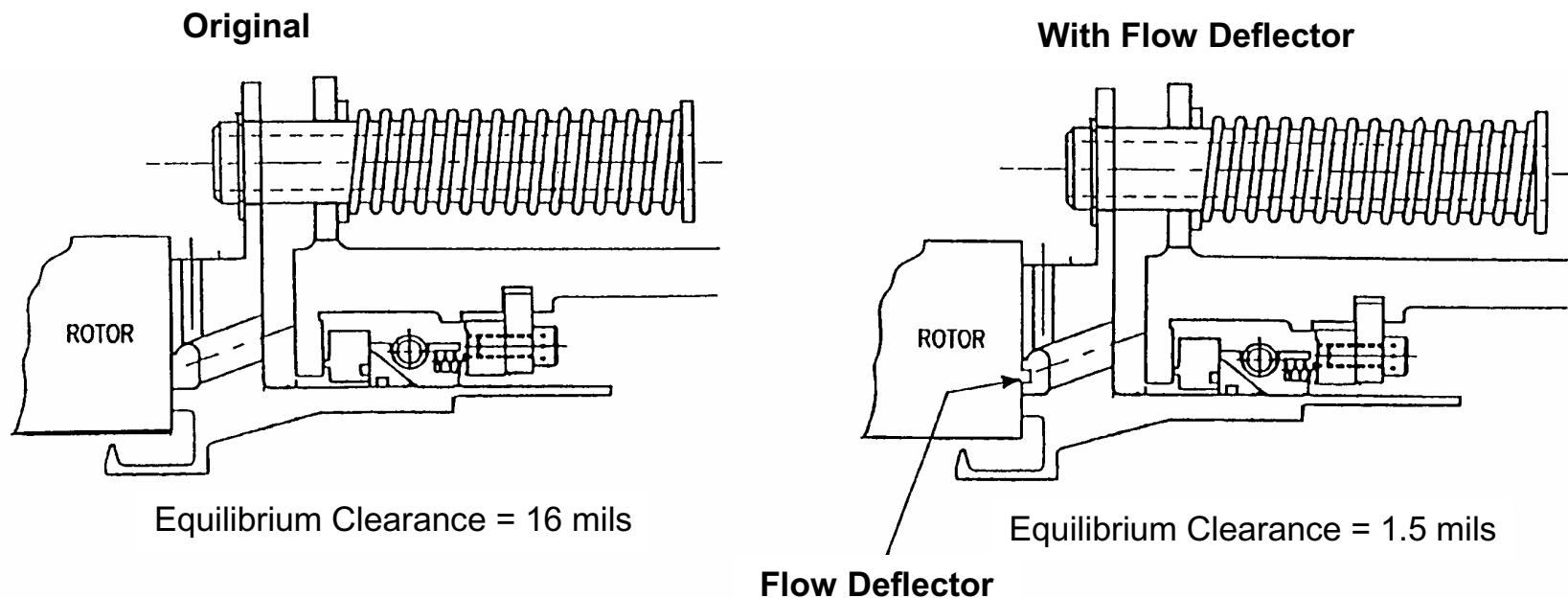


Variation of Load Capacity, F2, at the Seal Dam with Pressure Drop

Note: Loads were Derived from SCISEAL.

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Seal / Rotor Configurations



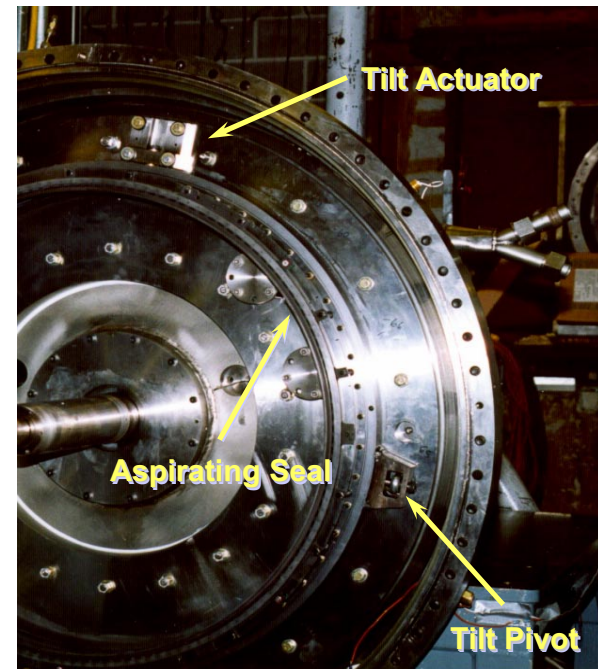
Flow Deflector Eliminates the Mixing of Flows from Air Dam and Air-bearing Regions.

- Mixing Flows Produce Excessive Pressure within Air-bearing Region

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List of Accomplished Aspirating Rig Verification Tests

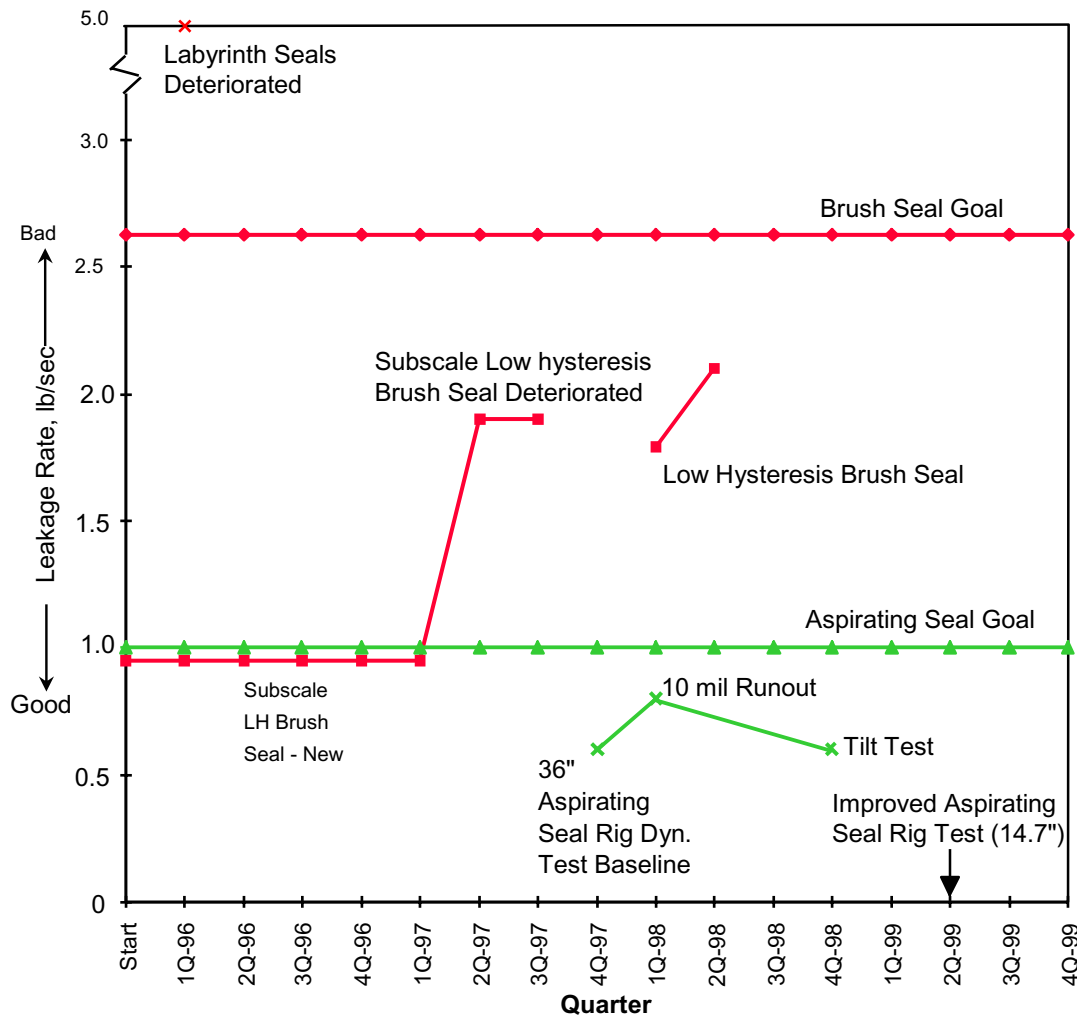
- 15-inch Diameter Subscale Tests
 - 1000 hours Endurance Test
(760 fps, 1000°F, 99 psid)
 - Dust Ingestion Test
(400 fps, Room Temperature, 100 psid)
- 36-inch Diameter Full-scale Rig Tests
(400 fps, Room Temperature, 100 psid)
 - Start / Stop Cycles
 - Runner Axial Face Runout: 5 and 10 mils
 - Simulated Maneuver Tilt



Full-scale Rig

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Seal Performance Comparison



Aspirating Seal

- Met Seal Leakage Goal
- Exhibited Less than Half Deteriorated Brush Seal Leakage
- Non-contacting Operation Provides for No Deterioration

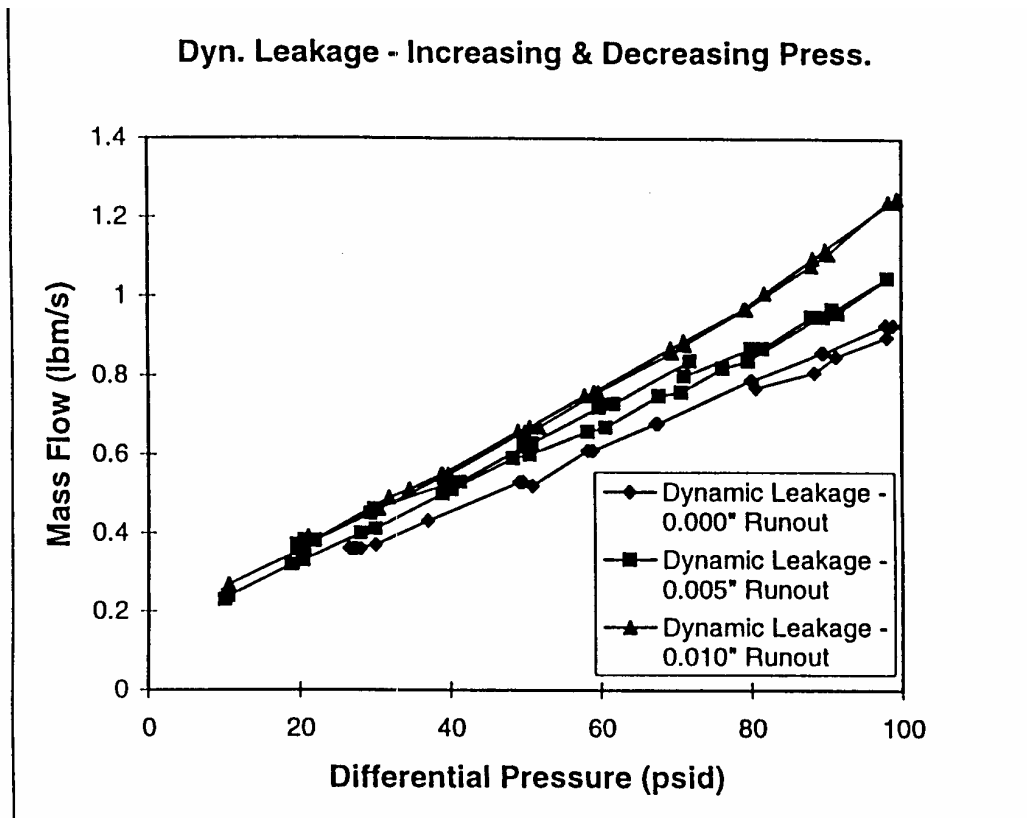
- Leakage Rate-Goals / Status for Brush Seals
- Aspirating Seals

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Test Results with Flow Deflector

at Room Temperature

Dynamic Leakage for 0.000, 0.005, and 0.010-inch Rotor TIR



- Seal Closure Occurs at 2-3 psid for All Cases

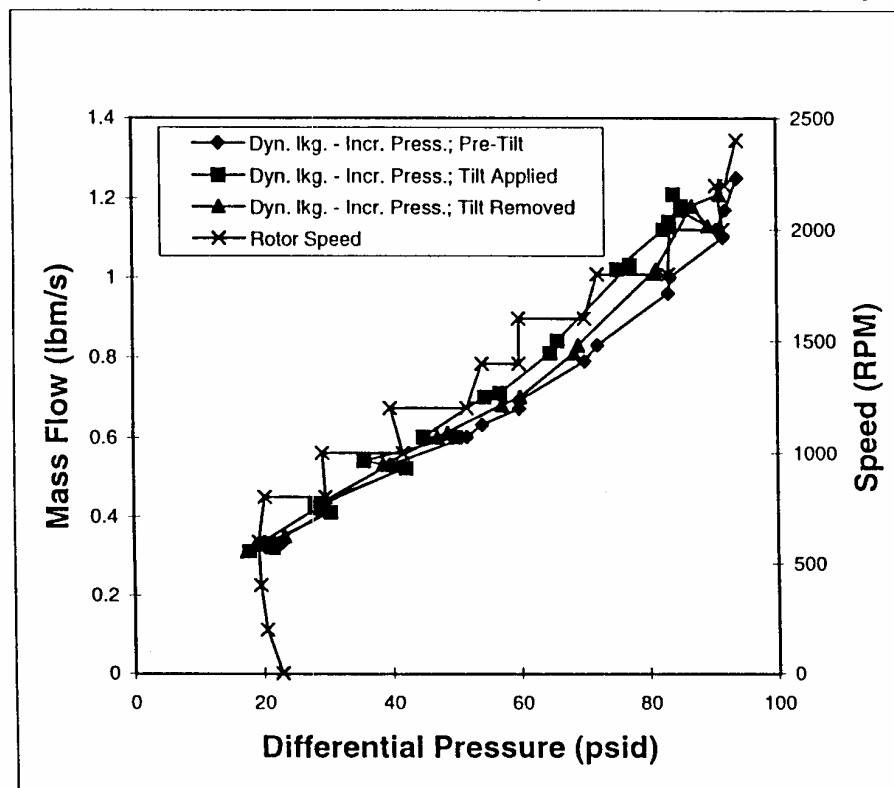
Aspirating Seal GE90 Test

Test Results - Dynamic Leakage with Tilt

at Room Temperature

Tilt 0.27° in 0.4 second, Hold to Collect Data, Remove in 0.4 second

Note: 0.007-inch Rotor Axial TIR, 141 μ in. Rotor Surface Roughness



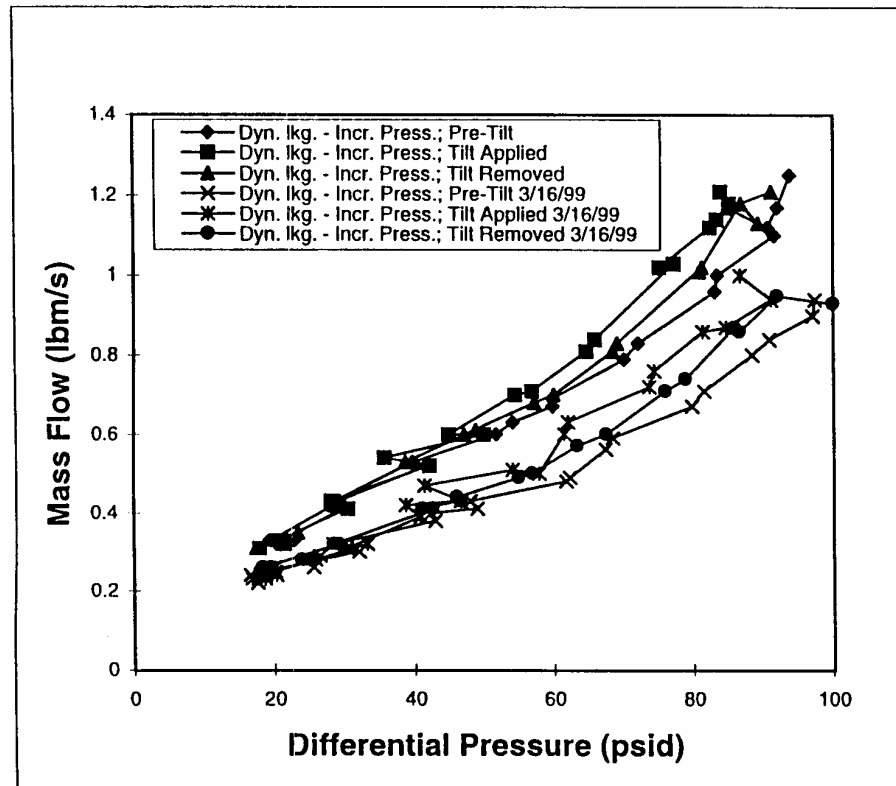
- At Maximum Conditions, Pressure Falls by 10% with Tilt While Leakage Remains Essentially Constant; Recovery Is > 95%

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Test Results - Dynamic Leakage with Tilt

at Room Temperature

Comparison of Seal Performance with 141 $\mu\text{in.}$ Rotor Surface Roughness
 and 13-19 $\mu\text{in.}$ Rotor Surface Roughness (03/16/99 data).

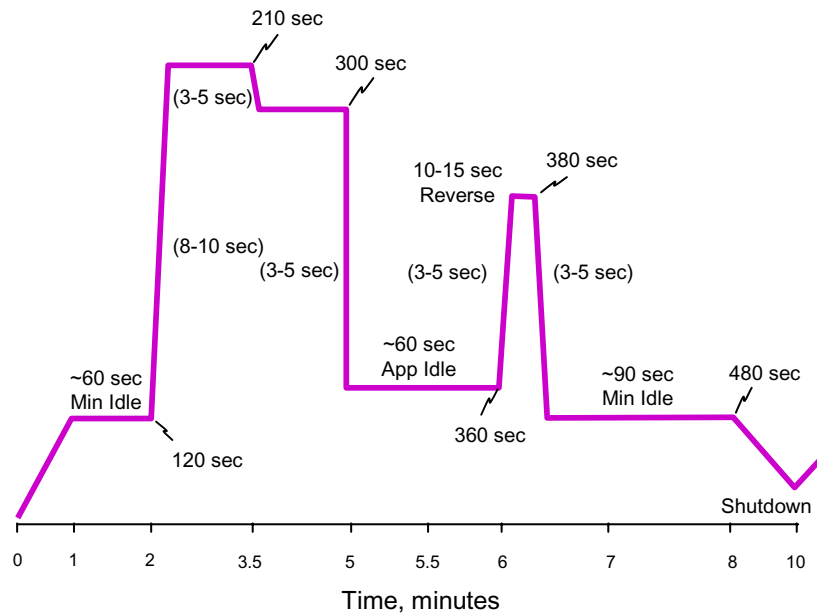


- Seal Performance Improves by 24% at Maximum Conditions When Rotor Surface Roughness is Improved to 13-19 μin

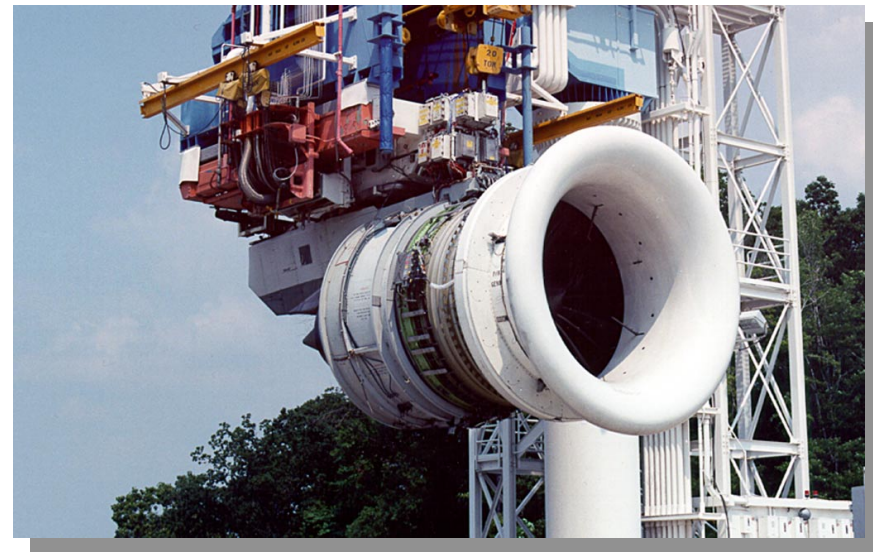
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Engine Test Plan: Test the Aspirating Seal “Piggyback” on a Previously Planned GE90 Development Test

Goal: 250 Test Hours with 1000 C-Cycles



C-Cycle



GE90 Test Stand

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Conclusions

- Aspirating Seal Designs were Fully Verified by Sub and Full-scale Rig Tests in Preparation for GE90 Engine Test
- All Engine Seal Hardware Fabrication was Completed
- Planned GE90 Test Date: 1st Quarter of 2002

